The long-term impact of U.S. bombing on education, earning, health, fertility and marriage in Cambodia

Chan Hang Saing*
Harounan Kazianga†

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Abstract

We use combined socio-economic surveys, demographic health surveys, and intensity of bombing to estimate the long-term impacts of U.S. bombing during 1969-1973 on education, earnings, health, fertility and marriage. The novelty of this paper consists of matching each geographic district with the quantity of bombs dropped in its vicinity, thereby allowing to estimate the effects of bombing intensity in addition to the binary exposure to bombing that has been reported in previous research. We find that one standard deviation increase in bombing during 1969-1973 reduced years of schooling by about 0.11-0.23 years. The effects for men are larger than those for women. We do not find any effect on earnings and employment and health, but find a 0.20 increase in total number of births and a 0.32 decline in age at first marriage per standard deviation increase in bombs.

Keywords: U.S. Bombing, Difference-in-Differences, Cambodia
JEL Codes:

*Department of Economics, Oklahoma State University, chan.saing@okstate.edu.
†Department of Economics, Oklahoma State University, harounan.kazianga@okstate.edu.

1 Introduction

Armed conflicts whether within or between countries bring about immediate and long-term consequences. Immediate negative effects are apparent ranging from destruction of capital and infrastructure, displacement of population, loss of social network, separation among family members, disruption of schooling and other economic activities, food shortage and health crises, delay in reproduction and marriage, and death of civilians and army. By contrast, long-term impacts are less apparent and evidence from existing studies are mixed.

Recent literature documents two lines of evidence. Studies that look at the aggregate effects measured by macroeconomic indicators such as Davis and Weinstein (2002), Brakman et al. (2004), Chen et al. (2008) and Miguel and Roland (2011) show that the negative consequences of civil conflicts do not persist decades later, while other studies that investigate the long-term consequences of conflicts at the micro level of households such as Ichino and Winter-Ebmer (2004), Akresh and de Walque (2008), Shemyakina (2011), Merrouche (2011), León (2012), Akbulut-Yuksel (2014), and Islam et al. (2015a, 2015b) find long-lasting effects on the outcomes of individuals several decades later.

This study adds to a growing body of literature on the long-term impacts of civil conflicts. First, unlike recent studies on armed conflicts in Cambodia, particularly by Islam et al. (2015a) who use years of exposure to conflicts by regions during 1970-1979 as a measure of atrocities inflicted by conflicts and Merrouche (2011) who uses landmine contamination intensity during 1970-1998, this study in turn uses intensity of U.S. bombing in Cambodia as a measure of destruction caused by civil conflicts during 1969-1973. No other study has used bomb intensity as a measure of the destruction of conflicts to examine the impacts at the micro level of households. Second, it contributes to the limited number of studies on the long-term effects of civil conflicts on earnings and marriage.

We use nationally represented surveys that we have access to, such as Cambodia Socio-Economic Survey (CSES) 2004, 2008, 2009 and 2010, Cambodia Demographic Health Survey (CDHS) 2000, 2005 and 2010, and data of U.S. bomb sites and apply difference-

in-differences (DID) approach to investigate the long-term impact of the bombing during 1969-1973. First, we find that one standard deviation increase in bombs during 1969-1973 reduced years of schooling by about 0.11-0.23 years. The effects for men are larger than those for women. Second, we do not find any effect on earning and employment for both men and women. Third, we find that U.S. bombing increased total number of births by about 0.20 per standard deviation increase in bombs, which suggests that U.S. bombing reduced non-monetary return to schooling. We also find that U.S. bombing increased age at first marriage among young female Cambodians, which is a factor contributing to a rise in fertility. Last, we do not find any effect on women's height, but predict that negligible effect could be due to comparing bombing-exposed individuals who were fittest during their childhood with non-exposed individuals since there was marked increase in number of deaths during early 1970s and our results also show that U.S. bombing reduced probability of survival among children aged under five.

The paper is structured as follows. Next section reviews existing evidence of long-term impacts of civil conflicts. Section 3 provides background of the U.S. bombing in Cambodia during 1965-1973, followed by data and descriptive statistics in section 4. Section 5 explains the identification strategy. Section 6 presents findings. Finally, section 7 concludes.

2 Literature

This section reviews some evidence of impacts of civil conflicts on education, earnings, fertility, health, and marriage. Islam et al. (2015a) examine the long-term consequence of civil war during 1970-1979 in Cambodia to find that individuals exposed to war during their primary school age accumulated about 2.5 and 3.5 months less years of schooling. Merrouche (2011) uses data on landmine contamination during 1970-1998 in Cambodia and finds that civil conflict reduced years of schooling of individuals who were too young to be enrolled in school before the war by 0.5 years. Likewise, using data of the aggregate residential rubble

per m^3 per capita in Germany as a measure of the intensity of World War II (WWII) destruction, Akbulut-Yuksel (2014) shows that 40 years later war-exposed children received on average about 0.3 less years of schooling in their adulthood. Using data on regional political violence in Perú, León (2012) also finds that individual exposed to political violence acquired about 0.31 less years of education.

There is also a growing evidence of the effects of civil conflicts on earnings. Islam et al. (2015a) find that civil conflict affected earnings through a reduction in education, where one year exposure to conflict reduced average earning of men between 6.6 and 8.6 percent. Similarly, Akbulut-Yuksel (2014) finds that WWII destruction in Germany reduced male earnings through education about 9 percent. Ichono and Winter-Ebmer (2004) find that individuals who were ten years old during conflicts in Austria and Germany suffered from both educational loss and substantial reduction in earnings during their adulthood compared with individuals of other cohorts. On the contrary, Merrouche (2011) looks at long-term impacts on earning in Cambodia, and unlike Islam et al. (2015a) she uses different measures of atrocities and longer period of civil conflicts. She finds no effect of conflict on earnings.

Studies on the effects of civil conflicts on fertility tend to focus on short-term impacts, such as Linsdrom and Berhanu (1999) and Agadjanian and Prata (2002), which document decline in fertility due to famine, economic shock and political violence in Ethiopia and Angola, respectively and Verwimp and Van Bavel (2005), which find a rise in fertility among Rwandese female refugees due to civil conflicts. Islam et al. (2015a) look at long-term impacts on fertility in Cambodia and find that conflicts increased number of birth per woman via reduction in females' years of schooling. Recent studies that find negative effects of armed conflicts on probability of ever married among women include Kesternich et al. (2014), Shemyakina (2013) and Schindler and Verpoorten (2013), while Valente (2011) finds positive effects on probability of being married of Nepalese women who were at school age during conflict, but finds no effects among women who were at marriageable age during conflicts.

Several studies find negative impacts of in-utero or early childhood exposure to con-

flicts of individual on their health outcomes during adulthood including Islam et al. (2015b), Akbulut-Yuksel (2014), Akresh et al. (2012), and Minoiu and Shemyakina (2012, 2014)[1]. Islam et al. (2015b) use sex ratio and mortality rate as measures of intensity of the genocide in Cambodia (1975-1979) and find negative effects of the genocide on height-for-age z-score of children born to parents who were at their prime-marriage age (14-29) during the genocide. Akbulut-Yuksel (2014) finds that children exposed to the average destruction of the WWII in Germany are about 6 inches shorter during their adulthood than others not exposed to the war.

3 U.S. Bombing in Cambodia (1965-1973)

U.S. bombing started in 1965 and last until August 1973. The original aim of the operation was to bomb the Ho Chi Minh Trail which passed through Lao and Cambodia. The magnitude of the bombs dropped during the period was around 2,756,941 tons, higher than the 2 million tons of bombs dropped by the Allies during World War II (Owen and Kiernan 2006). Since population of Cambodia in the 1960s was about 7 million, U.S. bombing translates into hundreds of kilograms of bombs per capita. The bombing during 1965-1968 was much smaller in scale than that during 1969-1973 as indicated in Figures 1a & 1b. The most intense bombing operation was between March and August 1973. By total weight of bombs during 1965-1973, general purpose bomb was about 84.6 percent, while cluster bomb and incendiary were around 6.2 percent and 5 percent, respectively. Interestingly, bombing operation with confirmed enemy location was only 33.8 percent of the total bomb sites during the period, while the rest of the targets covered a long list of locations and facilities. Additionally, by weight of the bomb only 26.4 percent were dispatched to the confirmed enemy location.

Figure 2a shows that more than half of the country was covered by U.S. bomb sites, which expanded from areas along Cambodia-Vietnam border to the center of the country.

[1]See Almond and Currie (2011) for a review of long-term effect of fetal (in-utero) and childhood shocks, particularly the "fetal origins" hypothesis.

Provinces located along the border such as Kampong Cham, which was the sole province that grew rubber trees and generated substantial revenue to the national economy, received the heaviest bombs, which were about 20% of total bomb weight, while others located in the West of the country, such as Banteay Mean Chey and Pailin, were not under any ariel strike (Figure 2b). Province is Cambodia's first-level administrative unit above district.

Given the magnitude of the bombs, it is likely that there is long-term negative consequence on human capital accumulation, adult's earnings, health, fertility and marriage. Since bombing disrupts schooling through destruction of school buildings and displacement of population, its effect on earnings runs through reduced educational attainment (Islam et al. 2015a). The effect on earning work through child health either during nine-month in utero or early childhood, which determines adult health and their educational attainment (Barker 1995). Massive destruction of paddy rice production, as well as its stock, due to bombing and ground offensive had some implications for malnutrition among children as well as mothers, which transmitted to fetal health. Additionally, it also affects fertility decision through delay in marriage, separation among couples due to male conscription and reduced fecundity due to psychological stress (Linstrom and Berhanu 1999), risk-insurance or old-age security approach to fertility, also known as replacement theory (Verwimp and Van Bavel 2005) and reduced years of schooling among women (Schultz 1994). Nonetheless, it also increases marriage probability among women since parents fear that their single daughters are more likely to fall victims of the army than married ones (Valente 2011).

4 Data

We combine Cambodia Socio-Economic Survey, as well as Cambodia Demographic Health Survey, with data on U.S. bomb sites with geographic coordinates between 1969 and 1973 for our analysis. CSES is a nationally representative survey which is carried out by the National Institute of Statistics under the Ministry of Planning of the Royal Government of Cambodia.

Sampling design of the survey follows three-stage sampling process starting from villages to enumeration areas and households. The survey collects information related to household demography, housing, agriculture, education, income and liability, and consumption. We use survey rounds that we can access, which include CSES 2004, 2008, 2009 and 2010.

CDHS is a USAID-funded project, which aims to collect detailed and reliable information on fertility history, family planning, maternal and child health and mortality. Household-level information, such as ownership of durable goods and housing materials, as well as individual-level information, such as demographic characteristics is collected using household questionnaire. Then, eligible males and females aged between 15 and 49 are identified for separate individual interviews. We use eligible women sample for the analysis of health, fertility and marriage of female individuals. First CDHS data was collected in 1998, followed by 2000, 2005, 2010, and 2014. GPS datasets were collected from 2000 onward, but the 2014 one is not publicly available yet. Hence, we are able to pool years 2000, 2005 and 2010 and geocode them into a district map.

Data on U.S. bomb sites during 1969-1973, which is used as a measure of atrocity, are from the Cambodia Genocide Program at Yale University library[2]. The data contain geographic coordinates of each bomb site, weight of bomb, bomb damage assessment, type of ordnance and target. We construct spatial intensity of U.S. bombing at district level. First, U.S. bomb sites are geocoded into district map of Cambodia (177 districts), where bomb weights are summed for each district. Then, to obtain data for the analysis of education, earning and employment, we manually merge district bomb intensity with each year of CSES data using district names. To do so, existing district codes of the district map are manually assigned to each district in each CSES year. Similarly, to obtain data for the analysis of fertility, health and marriage, we first geocode CDHS cluster sites into district map and merged it with CDHS data using cluster codes. We also geocode CDHS cluster sites into district map, which is already combined with bomb sites. The two datasets are then combined

[2]http://gsp.yale.edu/case-studies/cambodian-genocide-program/cambodian-genocide-databases-cgdb/geographic-database-cgeo

using cluster codes. Table 1 provides summary statistics of outcomes of interest and other explanatory variables.

5 Identification strategy

Figures 3a & 3b plot average years of schooling of individuals by year of birth. Figure 3a shows that average years of schooling of individuals born about a decade before 1969 is lower than that of those born earlier. Similar trends are also evident for individuals born in either high or low bomb intensity districts as shown in Figure 3b. One striking pattern indicated in Figure 3a is that individuals born about a decade before U.S. bombing (1969-1973) or Lon Nol regime (1970-1975) gained average years of schooling lower than those born earlier. This is qualitatively justifiable as children normally start school between 7 and 12 years of age. Hence, conflict might have some effects on years of schooling of individuals who were at primary school age at the start of the bombing or were already enrolled in primary school during the bombing.

We exploit the exogenous variation in the intensity of U.S. bombing, as well as timing of exposure of individuals to the bombing to estimate the effect of bombing on outcomes of our interest. Since the magnitude of bombing during 1965-1968 was too small to have any effect[3], we use bombing during 1969-1973 only. An individual's year of birth determines timing of exposure. Primary school age in Cambodia is between 6 and 12. Since on average children might start school late during 1950s and 1960s, we use age 7-12 as primary school age. Our treatment group are those who were between 7 and 12 (born between 1957 and 1962) in 1969, while the comparison group are those older than 12 or born during 1950-1955 (refer to Table 1 in Appendix). We apply DID approach similar to Duflo (2001) by

[3]We also compare individuals who were at their primary school age during 1965-1968 with the control group who were born during 1945-1951, but the effect from DID estimate is extremely small at 0.00027 per standard deviation of bomb.

estimating the following equation:

$$y_{ijkr} = \alpha + (bomb_j * young_{ik})\beta + \mu_j + \delta_k + \lambda_r + \rho' X_{ijk} + \sum_{p=1}^{4}(zone_p * trend)\theta_p + \varepsilon_{ijk} \quad (1)$$

where y_{ijkr} is either years of schooling completed, log monthly earning, fertility, age at first marriage or height of individual i, born in district j at year k and survey year r. And, $bomb_j$ is the level of regional bomb intensity measured in thousand metric tons in district j, while $young_{ik}$ is a dummy variable indicating that individual i was at primary-school age (7-12) during the bombing period. μ_j is district specific fixed effects which controls for the fact that districts may differ systematically from each other, and δ_k is year of birth or cohort fixed effects. λ_r is survey round fixed effects. Morever, X_{ijk} is a vector of additional controls including sex and ethnic Khmer dummy. ε_{ijk} is an error term.

For robustness check, we also control for $zone_p * trend$, which is the interaction between zone dummies and year of birth dummies to account for the differential trends of outcomes across the five zones, which are geographic units above province and district. Standard errors are clustered at district level to account for intra-regional correlation of outcomes of individual in the same district. We also apply White's standard error correction to obtain valid test statistic for our estimates. In this specification, β measures the effects of U.S. bombing between 1969-1973. Interpretation of this estimate relies on the assumption that education and earning of household in affected and non-affected districts do not differ systematically in absence of the bombing. In other words, β would have been zero in the absence of the U.S. bombing.

6 Results

6.1 Education

Results in Table 2 reveal negative long-term educational consequences of U.S. bombing during 1969-1973 in Cambodia, which is consistent with findings by Islam et al. (2015) and Merrouche (2011). DID estimates from all samples are statistically significant at 5 percent levels. Estimate from CSES full sample as indicated in column (1) shows that a standard deviation increase in U.S. bombing reduced years of schooling completed by about 0.11 years (0.0045*25.369), while the effect from earning sample shown in column (3) is about 0.23 years (0.0092*25.369) per standard deviation increase in bombs. If we measure at the average number of years of exposure (3 years) and average amount of ordnance dropped (15.798), for earning sample on average U.S. bombing reduced years of schooling by about 0.44 years (0.0092*15.798*3), lower than the average loss of 0.7 or 1.0 years of schooling in Islam et al. (2015a), which use years of exposure as a measure of intensity of conflicts and covers the periods of 1970-1979. Estimate from DHS sample shown in column (5) is about 0.14 drop in years of schooling per standard deviation increase in bomb. Our results are also robust to adding zone trends (Table 3 in Appendix).

There are multiple channels through either demand or supply sides that bombing disrupted schooling of young primary school-age Cambodians. Because of absence of data, we cannot test each channel, but we can only speculate with some anecdotal evidence. Negative effects from the supply side include school destruction and teacher's absence, while those from the demand side include fear for children safety and displacement. First, school destruction resulted from massive bombardment is apparently one primary reason that children stopped attending schools. Can (1991) claims that there was significant destruction of school buildings owing to the bombing, but provides no exact number. Second, parents might have drawn children from school for safety reason. During the last week of the bombing campaign, Ecole Wat Phnom, a private primary school in the center of Phnom Penh, was hit by the bomb when classes were in progress (Ayres 2000:67).

Third is disruption through displacement as homes were ravaged and paddy rice fields were either under siege by combat or destroyed by bombing. Two-month ground invasion by South Vietnamese Army (SVA) in 1970 generated about 130,000 refugees, sixty percent of whom were displaced, while there were incidents that villages were completely levelled and subsequently abandoned during the last six months of the bombing (Kiernan 1989). This also affected supply side as some teachers would take refuge in the city, while other would leave for France (Ayres 2000:80). Rural displaced population who were most severely affected by the bombing campaign would first move into the provincial town and later into the capital city (Phnom Penh) for safer ground (Becker 1998 and Shawcross 1987). In few months after the war started, the population in Phnom Penh, the capital city of Cambodia, swelled from around 700,000 to over 1.2 million (Tully 2005:164). By the end of 1971, about one third of Cambodia's seven million population were displaced (Shawcross 1987:222).

6.2 Heterogeneity of impact on education by gender

We also compare impact of U.S. bombing on education for men with that for women by adding interaction term between $bomb_j * young_{ik}$ and sex_{ik} to our estimation equation (1). DID estimates are in columns (2), (4) and (6) in Table 2. Estimates from both CSES samples are negative and similar in size suggesting that U.S. bombing affected schooling for men more than that for women. A standard deviation increase in bombs reduced years of schooling for men about 0.19 years (0.0075*25.369) as much as that for women. DID estimate from CDHS sample shown in column (6) is also negative and marginally higher than those from CSES samples. The effect is about 0.25 years per standard deviation increase in bombs. All DID estimates in this section are also robust to adding zone trends (Table 3 in Appendix).

Low enrolment rate among women relative to men during 1950s and early 1960s might be one reason underlying the difference in impacts since number of women who were at primary school age and never attended school during the periods were about 3 to 4 times as low as that of men according to census 2008. Moreover, child soldiers aged 10 to 15 during

1970-1975 could be another factor, but this explanation should be taken with caution owing to absence of statistics. Seaman (1999) claims based on reports from various journalists that there was use of child soldiers by Lon Nol's regime and the Khmer Rouge army during 1970-1975, but provides no concrete accounts and statistics of the its extent and scope. It is also worth noting that young boys were more preferred by the Khmer Rouge to young girls since they were more ready to help during combat and easy to be indoctrinated. Thus, young boys from the peasant family were more likely to be abducted than girls by the Khmer Rouge during their ambush of the villages.

6.3 Earnings

Table 3 presents results of the effects of U.S. bombing on earnings and employment for both men and women. Although results in the preceding sections show that the effect on education for men is larger than that for women, results in Table 3 do not reveal any effects of the bombing on earnings and employment for both groups. DID estimates of log monthly earning for both men and women are negative, but statistically insignificant as indicated in columns (1), (2) and (3) in panel A. The effects on employment as shown in the same columns in panel B are also negative, but statistically insignificant either.

Our results are consistent with those in Merrouche (2011) who looks at the effects of land mine contamination over 1970-1998 period in Cambodia. The effects on earnings for women in our study are also in support for the results in Islam et al. (2015), but not the effects on earnings for men. Since additional year of schooling increases earning for men about 7.5% and for women about 7.1% (Table 2 in Appendix), reduction in years of schooling by between 0.11 and 0.23 years due to U.S. bombing should not have an effect on earning for both men and women.

Another conjecture to this is that the effect of U.S. bombing on earning may work through the supply of labor. There could be positive wage gain due to the decline in labor supply since there was a spike in number of deaths of siblings during early 1970s, the period

of bombing, as shown in Figure 4. Additionally, column (1) in Table 4 in Appendix shows that U.S. bombing reduced survival probability of siblings. Thus, this may offset the effect due to reduction in years of schooling. On the other hand, although bombing does not have any effect on monetary return to education, we argue that it had an effect on non-monetary return since it increased fertility. For instance, the positive effect of bombing on fertility as shown in column (1) in Table 4 provides explanation to this argument since women's education has negative effect on fertility (Schultz 1994). Islam et al. (2015) also find that civil conflict in Cambodia during 1970-1979 increased fertility through reduction in years of schooling.

6.4 Fertility and marriage

This section looks at impacts of U.S. bombing on fertility and marriage, which are shown in columns (1) and (2) in Table 4. DID estimate for fertility is positive and statistically significant at 5 percent, while estimate for age at first marriage is negative and statistically significant at 10 percent. A standard deviation increase in U.S. bombs led to about 0.20 increase in total number of births and 0.32 decline in age at first marriage. Since more women were married due to fear of their being abused by soldiers it is reasonable to believe that the decline in age at first marriage might lead to an increase in total number of births. A rise in fertility is also the result of the decline in years of schooling owing to U.S. bombing, which is shown in section on education and in line with findings by Islam et al. (2015a).

In context of Cambodia, children are potential sources of old-age insurance for their parents, as well as short-term insurance to negative income shock of their parents. This is in line with risk-insurance or old-age security approach (replacement theory: high child mortality due to shocks puts pressure on household to replace lost one). Vierwimp and Van Bavel (2005) test this old-age security approach in context of Rwanda and find that fertility of women refugee rose in response to civil conflicts. Figure 4 shows that there was a marked increase in number of sibling deaths in early 1970s. Moreover, column (1) in Table 4 in

Appendix shows that U.S. bombing reduced probability of survival among siblings, while column (4) in the same Table also shows that the bombing reduced probability of survival among children aged under 5. Therefore, households residing in districts that were more severely bombed were more likely to die and lose their children. Since our results also show that U.S. bombing increased fertility it is likely that households who lost their children or siblings due to bombing were more likely to replace their lost ones.

6.5 Health

Since we are interested in impact of U.S. bombing on individuals who were in-utero and younger than 5 years of age during the bombing, our treatment group are individuals born between 1965 and 1969, while our control group are those who were born between 1960 and 1964. We run OLS on specification equation (1) to obtain estimate of the impact, which is shown in column (3) in Table 4. DID estimate is negative, but small and statistically insignificant, which suggests that there is no evidence of impact of U.S. bombing on health among female individuals.

However, the situation of malnutrition was widespread during the bombing period since by the end of 1971 more than 2 million of Cambodian's 7 million population were displaced and about 20 percent of country's property were destroyed (Shawcross 1987:222). Moreover, by around August 1971 the North Vietnamese Army (NVA) had occupied more than half of the country's territory (Becker 1998:130). There was also substantial reduction in paddy rice production as large paddy rice fields were either destroyed or under the control of the NVA. Disease such as gastric disorder, which could have been cured if there had been sufficient medical supplies, was very common among children (Shawcross 1987:223). Therefore, the absence of the effect might be because individuals selected into the sample are the fittest survivors meaning that we compare bombing-exposed individuals who were fittest with non-exposed individuals to estimate the effect.

To investigate whether there is evidence of survival of the fittest, we run OLS on

specification equation (1), where dependent variables are probability of being alive of siblings, children under five years of age and adult aged above 17 years. Results are in Table 4 in Appendix. Column (1) shows that U.S. bombing reduced survival probability of siblings, while column (2) shows no effect of U.S bombing. This suggests that individuals exposed to bombing at younger age were not affected and were more likely to be fittest children to survive through the bombing period. Column (4) provides additional support to this since U.S. bombing reduced probability of survival among children aged under five, which suggests that child mortality during the bombing period was probably high. Furthermore, results in columns (5) and (6) show no effects of U.S. bombing on survival probability of adults. Thus, we can qualitatively argue that absence of the effect is attributed to selection of the fittest survivors into the sample.

7 Conclusion

Armed conflicts cause both immediate and long-term consequences, the evidence of its long-term impact of which has been documented at both macro level and micro level of households. The U.S. bombing in Cambodia during 1965-1973 was the sideshow of the Vietnam war, and it was so massive that about a third of its total population were displaced and large number of schools, paddy rice fields and infrastructures were destroyed, which suggests its long-term impact on households who resided in districts with high bomb intensity. This study uses two sources of variation, namely bomb intensity at district level and birth cohorts exposed to the bombing period by applying DID approach to identify impact of U.S. bombing on education and earning. We find that one standard deviation increase in U.S. bombs during 1969-1973 reduced years of schooling between 0.11 and 0.23 years. The effects on years of schooling for men are higher than those for women.

We do not find any effect on earning and employment for both men and women. Nonetheless, we find that U.S. bombing increased total number of births by about 0.20

per standard deviation increase in bombs, which suggests that U.S. bombing reduced non-monetary return to schooling. We also find U.S. bombing increased age at first marriage among young female Cambodians, which is a factor contributing to the rise in fertility. However, we do not find any effect on women's height, but predict that negligible effect could be due to comparing bombing-exposed individuals who were fittest during their childhood with non-exposed individuals since there was marked increase in number of deaths during early 1970s and our results show that U.S. bombing reduced probability of survival among siblings as well as children aged under five.

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Figure 1a: US ordance in metric ton dropped in Cambodia 1965–1969

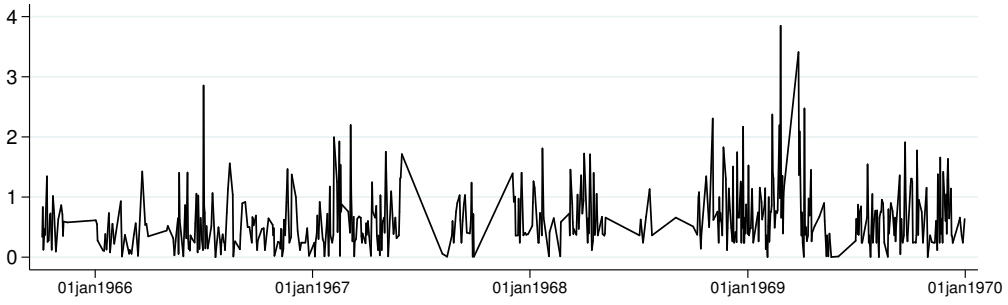


Figure 1b: US ordance in metric ton dropped in Cambodia 1970–1973

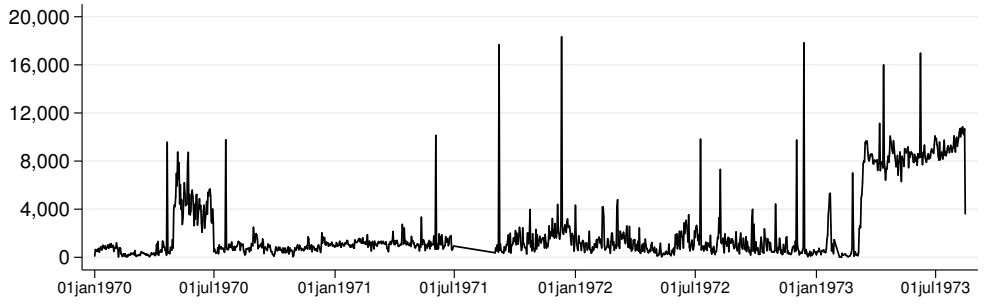


Figure 2a: US bombing sites 1965-1973

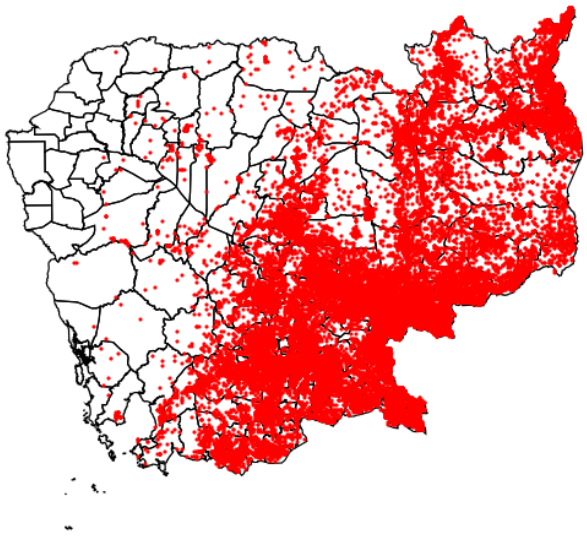
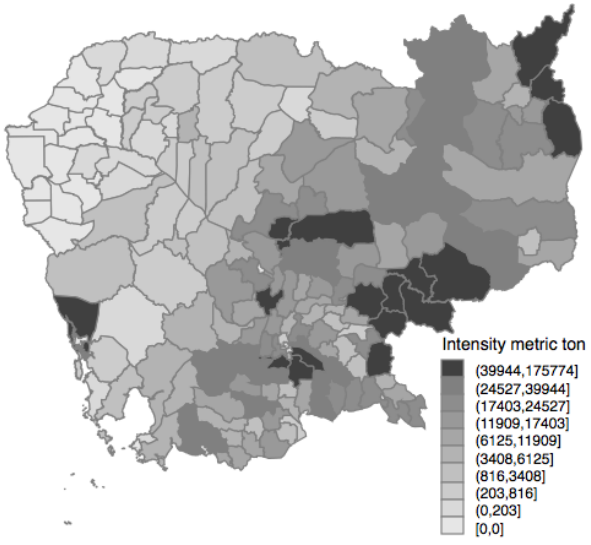


Figure 2b: US ordnance dropped on districts of Cambodia 1965-1973



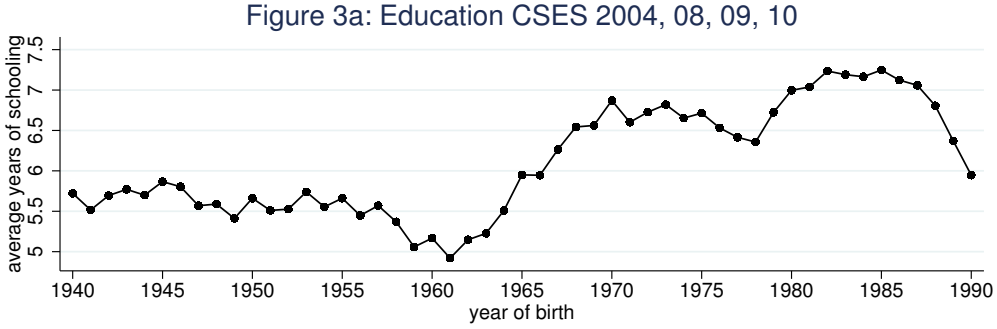


Figure 3a: Education CSES 2004, 08, 09, 10
average years of schooling
5
5.5
6
6.5
7
7.5
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
year of birth

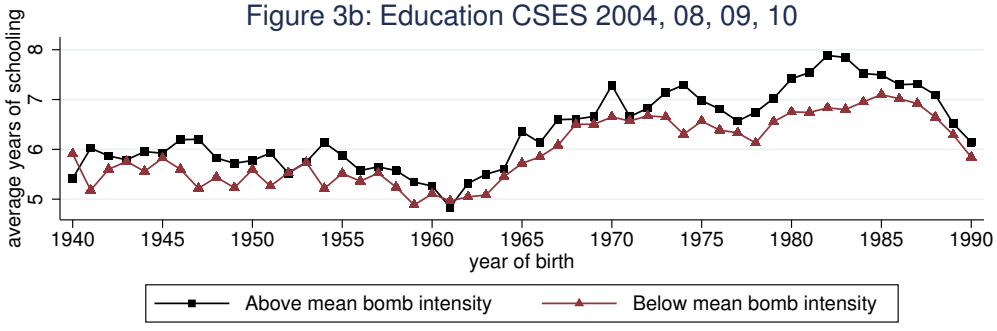


Figure 3b: Education CSES 2004, 08, 09, 10
average years of schooling
5
6
7
8
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
year of birth
Above mean bomb intensity
Below mean bomb intensity

Figure 4: Mortality of siblings of women aged 15-49 (CDHS 2000, 2005, 2010)

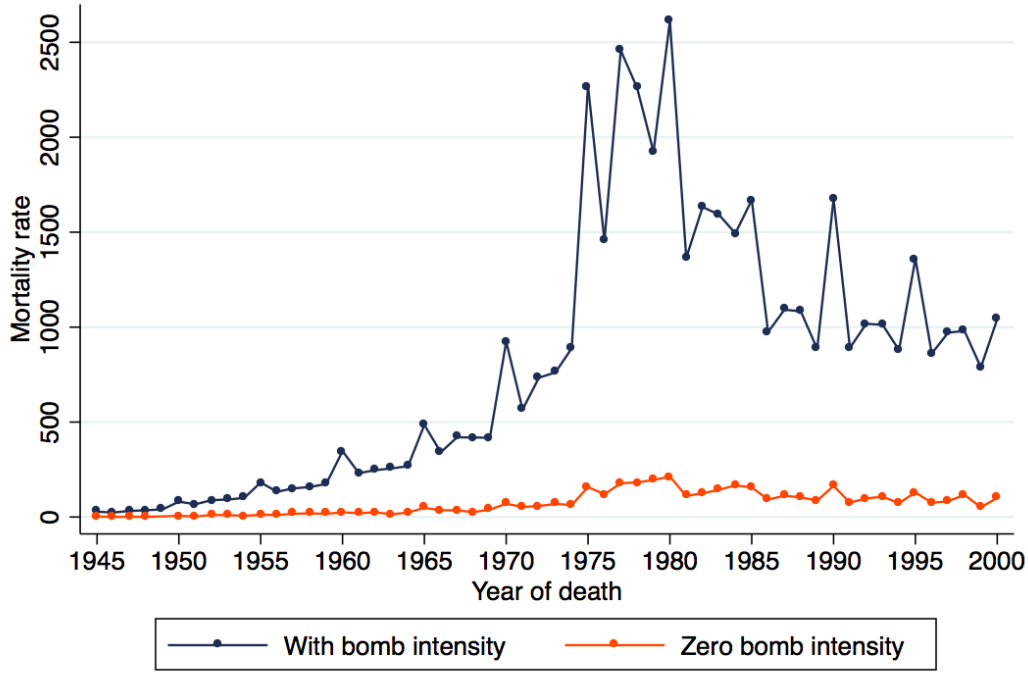


Table 1: Summary statistics of the main variables in the analyses

	Mean	S.D	N
Panel A: CSES (2004, 2008, 2009, 2010)			
Full sample			
Years of schooling completed	3..76	3.67	16,424
Age	49.55	4.63	16,511
Sex (male=1)	0.43	0.49	16,511
Marital status (single=1)	0.03	0.17	16,509
Ethnic dummy (Khmer=1)	0.96	0.19	16,504
Urban	0.25	0.43	16,511
Earning sample			
Years of schooling completed	4.55	4.18	6,599
Monthly earnings in Riels	149,173.60	364,371.40	6,599
Log monthly earnings	10.80	1.57	6,599
Age	47.75	4.12	6,599
Sex (male=1)	0.59	0.49	6,599
Marital status (single=1)	0.02	0.15	6,598
Ethnic dummy (Khmer=1)	0.96	0.19	6,599
Urban	0.29	0.45	6,599
Panel B: DHS household sample (2000, 2005, 2010)			
Years of schooling in single year	3.22	3.17	21,834
Age	48.25	5.67	21,980
Sex (male=1)	0.42	0.49	21,980
Urban	0.17	0.38	21,980
Panel C: DHS women sample (2000)			
Height (centimeters)	152.57	9.09	2,008
Number of children ever born	5.48	2.64	3,768
Age at first marriage	19.98	4.34	3,768
Urban	0.16	0.36	3,768
Panel D: U.S. bomb intensity			
District level			
Bomb '000 metric ton 1965-1973	15.799	25.370	177
Bomb '000 metric ton 1965-1968	0.001	0.004	177
Bomb '000 metric ton 1969-1973	15.798	25.369	177

Table 2: Impact of U.S. bombing on years of schooling

	CSES Full sample		CSES Earning Sample		DHS household sample (2000, 2005, 2010)	
Dependent variable: Education	(1)	(2)	(3)	(4)	(5)	(6)
Bomb*born 1957-1962	-0.0045**	-0.0014	-0.0092**	-0.0036	-0.0054**	-0.0001
	(0.0021)	(0.0019)	(0.0036)	(0.0047)	(0.0026)	(0.0026)
Bomb*born 1957-1962*sex		-0.0075***		-0.0076*		-0.0100***
		(0.0024)		(0.0042)		(0.0026)
Sex (male=1)		2.0660***		2.0095***		1.9954***
		(0.0655)		(0.0986)		(0.0832)
Ethnic Khmer (Khmer=1)		1.6057***		1.6037***		
		(0.1914)		(0.3097)		
Constant	3.8792***	1.5545***	6.1955***	3.5611***	3.5425***	2.7362***
	(0.1218)	(0.2191)	(0.4292)	(0.5445)	(0.0608)	(0.0553)
Observations	15,473	15,466	6,210	6,210	21,363	21,363
R-squared	0.1093	0.1908	0.1796	0.2365	0.1580	0.2454
District fixed effects	yes	yes	yes	yes	yes	yes
Cohort fixed effects	yes	yes	yes	yes	yes	yes

Notes: Standard errors are clustered at district level. Comparison group are individuals born between 1950 and 1955. Earning sample include both waged workers and self-employed workers aged between 17 and 57. *** Significant at 1%; ** significant at 5%; * significant at 10%.

Table 3: Impact of U.S. bombing on earning and employment for both men and women

	Both	Male	Female
CSES (2004, 2008, 2009, 2010)	(1)	(2)	(3)
Panel A: Log monthly earning			
Bomb*born 1957-1962	-0.0011	-0.0015	-0.0008
	(0.0013)	(0.0017)	(0.0017)
Observations	6,210	3,650	2,560
R-squared	0.3489	0.3967	0.3483
Panel B: Employment			
Bomb*born 1957-1962	-0.0001	-0.0001	-0.00004
	(0.0001)	(0.0001)	(0.0001)
Observations	6,210	3,650	2,560
R-squared	0.0462	0.0735	0.1295
District fixed effects	yes	yes	yes
Cohort fixed effects	yes	yes	yes

Notes: Standard errors are clustered at district level. Comparison group are individuals born between 1950 and 1955. Sample is restricted to those aged between 17 and 57. *** Significant at 1%; ** significant at 5%; * significant at 10%.

Table 4: Impact of U.S. bombing on fertility, marriage and health

	Fertility	Age first marriage	Height
DHS women sample (2000)	(1)	(2)	(3)
Bomb*born 1957-1962	0.0079**	-0.0125*	
	(0.0037)	(0.0074)	
Bomb*born 1965-1969			-0.0012
			(0.0242)
Observations	3,734	3,734	1,984
R-squared	0.1305	0.0606	0.0866
District fixed effects	yes	yes	yes
Cohort fixed effects	yes	yes	yes

Notes: Standard errors are clustered at district level. Comparison group are individuals born between 1950 and 1955 for fertility and age at first marriage, while comparison group for height are individuals born between 1960 and 1964. *** Significant at 1%; ** significant at 5%; * significant at 10%.

Appendix

Table 1: Years of birth exposed to US bombing during primary school age

Year of Birth	Age in 1969	Age in 1973	Age in 1975	Age in 1979	Treat=1	
1950	19	23	25	29	0	
1951	18	22	24	28	0	
1952	17	21	23	27	0	
1953	16	20	22	26	0	Not exposed
1954	15	19	21	25	0	
1955	14	18	20	24	0	
1956	13	17	19	23	0	
1957	12	16	18	22	1	
1958	11	15	17	21	1	
1959	10	14	16	20	1	U.S. Bombing
1960	9	13	15	19	1	
1961	8	12	14	18	1	
1962	7	11	13	17	1	
1963	6	10	12	16	1	
1964	5	9	11	15	1	Bombing & genocide
1965	4	8	10	14	1	
1966	3	7	9	13	1	
1967	2	6	8	12	1	
1968	1	5	7	11	1	
1969	0	4	6	10	1	
1970	-	3	5	9	1	Genocide only
1971	-	2	4	8	1	
1972	-	1	3	7	1	

Table 2: Returns to years of education (CSES 2004, 2008, 2009, 2010)

	Both sexes	Male	Female
Log monthly earnings	(1)	(2)	(3)
Education	0.0731***	0.0748***	0.0714***
	(0.0052)	(0.0065)	(0.0078)
Age	0.0516	0.1641	-0.0976
	(0.0958)	(0.1196)	(0.1449)
Age squared	-0.0006	-0.0018	0.0010
	(0.0010)	(0.0012)	(0.0015)
Sex (male=1)	0.1507***		
	(0.0368)		
	(0.0071)	(0.0084)	(0.0068)
Year 2004	-2.0962***	-2.2275***	-1.8930***
	(0.0907)	(0.1071)	(0.1301)
Year 2008	-0.3906***	-0.4615***	-0.1633
	(0.1336)	(0.1442)	(0.1624)
Year 2009	-0.3512***	-0.3836***	-0.3334***
	(0.0810)	(0.0888)	(0.1420)
Observations	6,210	3,650	2,560
R-squared	0.3840	0.4242	0.3732

Note: Standard errors are clustered at district level. Each model includes district fixed effects and sample is restricted to individuals aged between 17 and 57. *** Significant at 1%; ** significant at 5%; * significant at 10%

Table 3: Impact of U.S. bombing on years of schooling, fertility and age at first marriage

	CSES Full sample		CSES Earning Sample		DHS sample (2000, 2005, 2010)		DHS sample (2000)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Education	Education	Education	Education	Education	Education	Fertility	Age at first marriage
Bomb*born 1957-1962	-0.0046**	-0.0015	-0.0088**	-0.0032	-0.0054**	-0.0001	0.0098**	-0.0124
	(0.0022)	(0.0020)	(0.0037)	(0.0047)	(0.0026)	(0.0026)	(0.0041)	(0.0079)
Bomb*born 1957-1962*sex		-0.0074***		-0.0077*		-0.0100***		
		(0.0024)		(0.0040)		(0.0026)		
Sex (male=1)		2.0673***		1.9988***		1.9952***		
		(0.0656)		(0.0983)		(0.0832)		
Ethnic Khmer (Khmer=1)		1.5368***		1.5458***				
		(0.1860)		(0.3005)				
Constant	3.0864***	0.8641***	4.9427***	2.3530***	3.2741***	2.4473***	143.9811**	-3.4826
	(0.2799)	(0.3080)	(0.5313)	(0.6138)	(0.3822)	(0.3777)	(62.3280)	(64.9849)
Observations	15,473	15,466	6,210	6,210	21,363	21,363	3,734	3,734
R-squared	0.1184	0.1994	0.1923	0.2482	0.1583	0.2457	0.1330	0.0619
Add zone trend	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Standard errors are clustered at district level. Earning sample includes both waged workers and self-employed workers aged between 17 and 57. Comparison group are individuals born between 1950 and 1955. *** Significant at 1%; ** significant at 5%; * significant at 10%.

Table 4: Impact of U.S. bombing on probability of survival of siblings

Dummy variables	Sibling survival		Child survival (Age < 5)		Adult survival (Age >17)	
	(1)	(2)	(3)	(4)	(5)	(6)
Born1957-1962	0.1113***		0.0054		0.1548***	
	(0.0086)		(0.0049)		(0.0092)	
Bomb*Born1957-1962	-0.0007**		0.0001		-0.0004	
	(0.0004)		(0.0002)		(0.0003)	
Born1965-1969		0.0264***		-0.0056		0.0239***
		(0.0062)		(0.0039)		(0.0038)
Bomb*Born1965-1969		0.0000		-0.0003***		0.0001
		(0.0002)		(0.0001)		(0.0002)
Sex (female=1)	0.1766***	0.0786***	0.0103***	0.0093***	0.1194***	0.0405***
	(0.0068)	(0.0056)	(0.0037)	(0.0033)	(0.0052)	(0.0036)
Year 2005	-0.0553***	-0.0478***	-0.0143***	-0.0180***	-0.0394***	-0.0291***
	(0.0118)	(0.0096)	(0.0053)	(0.0053)	(0.0074)	(0.0033)
Year 2010	-0.0553***	-0.0478***	-0.0143***	-0.0180***	-0.0394***	-0.0291***
	(0.0118)	(0.0096)	(0.0053)	(0.0053)	(0.0074)	(0.0033)
Constant	0.5657***	0.7485***	0.9417***	0.9449***	0.6928***	0.9152***
	(0.0093)	(0.0065)	(0.0040)	(0.0035)	(0.0072)	(0.0032)
Observations	37,002	50,312	37,002	50,312	37,002	50,312
R-squared	0.0661	0.0286	0.0216	0.0178	0.0746	0.0206
District fixed effect	yes	yes	yes	yes	yes	yes

Notes: Standard errors are clustered at district level. Comparison group for individuals born during 1957-1962 are those born between 1950 and 1955, while comparison group for individuals born during 1965-1969 are those born during 1960-1964. *** Significant at 1%; ** significant at 5%; * significant at 10%.